Intercontinental ballistic missile R-7 (8K71) / R-7A (8K74)

Classification:

Based:	Ground launcher
Purpose:	Strategic
Warhead:	Special ammunition
Control system:	Software control , Radio control
A country:	Russia
Range:	9500 km.
Year of development:	1960

The world's first intercontinental ballistic missile R-7 (8K71) carried a thermonuclear warhead and could deliver it to almost any point in the territory of a potential enemy. Preliminary research on the creation of such a rocket began in 1950. when performing work on topic H3 "Study of the prospects for creating various types of rocket engines with a flight range of 5000-10000 km with a warhead weight of 1-10 tons. " The topic was carried out according to the Decree of the Council of Ministers of the USSR of December 4, 1950. The country's leading scientific and industrial organizations were involved in the work: OKB-1 NII-88 (SP Korolev), OKB-456 (VP Glushko), NII-885 (MS Ryazansky, NA Pilyugin), NII-3 (VK Shebanin), NII-4 (AI Sokolov), CIAM, TsAGI (AA Dorodnitsyn, VV Struminsky), NII-6, NII-125 (B.P.Zhukov), NII-137 (VAKostrov), NII-504 (SIKarpov), NII-10 (VIKuznetsov), NII-49 (AICharin), Mathematical Institute named after. AN Steklova (MV Keldysh) and others. In carrying out the topic, a wide range of problematic issues at that time were studied and ways to solve them were outlined, the fundamental possibility of creating “composite” ballistic missiles with a payload of 3-5 tons, operating using the “liquid oxygen” - kerosene” components, a detailed analysis of the rocket design, its optimal parameters, number of stages, initial mass, engine thrust and other characteristics were carried out.

The continuation of topic H3 was topic T-1 “Theoretical and experimental research on the creation of a two-stage ballistic missile with a flight range of 7000-8000 km.” The work was carried out in accordance with the Decree of the Council of Ministers of the USSR dated February 13, 1953. Within the framework of this topic, a preliminary design of a two-stage long-range ballistic missile weighing up to 170 tons with a detachable warhead weighing 3 tons for a range of 8 thousand km was developed. However, in October 1953, at the direction of the Deputy Chairman of the Council of Ministers of the USSR VA Malyshev, the mass of the warhead in the project was increased to 5500 kg (by that time the problem of creating thermonuclear charges with high specific power had not yet been solved) while maintaining the flight range, in due to this, a serious reworking of the project was required (since with a warhead of such a mass, the designed rocket could provide a range of no more than 5500 km) .

In January 1954, a meeting of the Chief Designers (SP Korolev, VP Barmin, VP Glushko, BM Konoplev, VI Kuznetsov, NA Pilyugin) was held with the participation of MI Borisenko, KD Bushuev, SS Kryukov and VP Mishin, at which the issue of further work on the rocket in connection with the increase in the mass of the warhead was discussed. At the meeting, it was decided to use a relatively small engine that is unified for all blocks, limiting the dimensions of the blocks allowing them to be transported by rail. Due to operating conditions, it was decided to abandon the usual launch pad and create ground equipment systems with an unconventional method of suspending the rocket on special discarded trusses, which made it possible to reduce the load on the lower part of the rocket and reduce its mass. To ensure the specified firing accuracy, the spread of the engine thrust aftereffect impulse had to be in a strictly fixed range, however, at the preliminary design stage, OKB-456 was unable to resolve this issue. Then it was decided for the first time to use steering chambers as control bodies, which would provide the final stage of thrust after turning off the main propulsion engine and the required aftereffect impulse. Due to VP Glushko's refusal to develop steering engines, this work was entrusted by SP Korolev to the head of the OKB-1 NII-88 department, MV Melnikov (later, when creating launch vehicles based on the R-7, steering engines were used developed at OKB-456).

May 20, 1954 a joint Resolution of the Council of Ministers of the USSR and the Central Committee of the CPSU was adopted on the development of a two-stage ballistic missile R-7 (8K71). The resolution determined: the main developer of OKB-1 NII-88 and co-executors: OKB-456 (engines), NII-885 (control systems), GSKBspetsmash (ground equipment), NII-10 (gyro devices), KB- 11 (special charge) and NII-4 MO (ground tests). By resolution of June 28, 1954 "On the R&D plan for special products" the content, order and timing of work on the R-7 rocket were clarified. In the order of the Minister of Defense Industry dated July 6, 1954. It was especially emphasized that the creation of the R-7 rocket is a task of national importance and all work must be completed within the specified time frame. SP Korolev, who headed OKB-1 NII-88, received broad powers to attract not only specialists from various industries, but also to use the necessary material resources. The preliminary design for the R-7 missile system was ready in mid-July 1954. Such a rapid pace was largely ensured by using the groundwork on the T-1 topic.

On November 20, 1954, the presented preliminary design of the R-7 (8K71) rocket was approved by the Council of Ministers of the USSR. In November 1954, a meeting was held at OKB-1 with the participation of KN Rudnev, VP Barmin, NA Pilyugin, MS Ryazansky and representatives of the customer. At the meeting, OKB-1's proposal to assemble the rocket package not vertically at the launch facility, as was envisaged in the design studies, was considered, but horizontally in the assembly housing with subsequent suspension in assembled form in the launch system by power units on the side blocks. The proposal was met with ambiguity: it was necessary to break the already established mechanism for organizing work, but the arguments in favor of the proposal were so weighty doubts that all disappeared by themselves. On March 20, 1956, a Resolution of the Council of Ministers of the USSR was adopted on measures to ensure testing of the R-7 missile and other measures to create favorable conditions for its development. The pace of work on developing the R-7 rocket increased sharply, and with it the workload on the performers, for whom lump sum wages and additional bonuses were introduced.

In addition to the working documentation for the standard rocket, documentation was created for full-size mock-ups for experimental testing of all rocket systems. In 1956, two sets of blocks A (central) and B (one of the side ones) were manufactured for bench tests and three prototypes for ground tests. At the same time, the first flight prototype was manufactured, factory control tests of which were carried out in branch No. 2 of NII-88 (later NII-229). Despite all the difficulties, the first flight sample of the R-7 rocket was sent to the test site at the end of 1956. In the second half of 1956, a decision was made to involve the Kuibyshev Aviation Plant "Progress" (A. Ya. Linkov) in the serial production of the R-7 rocket. The first missiles at the Progress plant were assembled from parts and assemblies manufactured at plant No. 88. Subsequently, a branch of OKB-1 was organized at the Progress plant, headed by Deputy Chief Designer DI Kozlov.

The novelty of the rocket design and new principles for constructing the launcher required a significant amount of experimental testing of the rocket systems and the rocket as a whole. It was also necessary to conduct training for the services of the newly created test site. For these purposes, a comprehensive testing program is being created, including:

- Testing of the developed radio control system for the R-7 rocket under real flight conditions on the R-5R rocket. Instead of the warhead, a container with R-7 onboard equipment was installed on the R-5R rocket. From May 31 to June 15, 1956, three successful launches of the R-5R rocket were carried out.
- Testing in real flight conditions of the control system of the R-7 rocket, consisting of: a system for simultaneous emptying of the tanks of the central block, a system for regulating the apparent speed; normal and lateral stabilization systems, the Tral telemetric system and the Fakel control system. Testing was carried out on the M5RD rocket at the GCP in two stages of five launches each (the first stage from February 16 to March 23, 1956, the second from July 20 to August 18, 1956). The test results were assessed as "positive".
- Testing the shock-free exit of a rocket from the launch system at the Leningrad Metal Plant (LMZ). The LMZ had concrete wells with a diameter of 19 m, intended at one time for the manufacture of gun turrets, and two 300-ton cranes. These tests made it possible to carry out a control assembly and check the functioning of all systems and assemblies of the new Tyulpan launcher, and to check the shock-free exit of the missile from the launcher. The tests were carried out with a prototype technological prototype of the R-7SN missile, which made it possible to fill the tanks with water with an anti-corrosion additive. To do this, the rocket was installed in the launcher, refueled to the launch mass and lifted (simulating a launch) by two cranes on a special traverse attached to the power heads of the side blocks. At the same time, the speed of movement and angles of the launcher elements extending from the rocket (lower guides), support trusses, cable masts, etc. were measured. Processing of the measurements taken by recalculating the experimental data, despite the insufficient completeness of the launch simulation (differences in the speed of the rocket exiting the launch device and other parameters), allowed us to conclude that the rocket exited the launch device without impact during a real launch. The Leningrad Metal Plant (LMZ) also developed the technology of assembling a rocket from transportable blocks into a “package”, the methodology and technology of installing a rocket on a launcher, transferring its mass to support trusses, verticalizing and turning the rocket at a given angle. Tests were carried out from June to September 1956, after which the launcher and R-7SN missile were disassembled to be sent to the test site. At the beginning of December 1956 The R-7SN missile arrived at the test site.
- Fire tests of rocket units and the rocket as a whole (from July 1956 to March 1957) at the bench base of branch No. 2 of NII-88. The tests included cold tests of single blocks in order to test the modes of filling and replenishing tanks with liquid oxygen and nitrogen, obtaining data on temperature

conditions in the tanks, fuel lines and compartments of the blocks, as well as fire tests of single blocks in order to check the starting modes and operation of the propulsion and steering engines as part of a propulsion system, checking the operability of engine power systems, obtaining data on temperature and vibration loads on structural elements of blocks, checking the real dynamic characteristics of the automatic stabilization equipment and systems for regulating apparent speed and emptying tanks. Five fire tests of three side blocks were carried out (August 15, September 1 and 24, October 11 and December 3, 1956), three tests of the central block (December 27, 1956 (block 2TSS), January 10 and 26, 1957 (block 1TSS)) and fire tests of two missiles assembled in a "package" (February 20 - "package" 2C, March 30, 1957 - "package" 4SL - flight version). Fire tests of all three side blocks were satisfactory. The propulsion systems were started in accordance with a given cyclogram. During preparation for fire tests of the first central unit after filling with oxygen, an accident occurred: due to water hammer, the tunnel pipe for supplying oxygen to the engine was destroyed. The cause of the accident was overheating of liquid oxygen in the tunnel pipe due to its large length. To eliminate this drawback, a constant flow of oxygen was introduced from the lower point of the pipeline to the discharge, which was subsequently replaced by a circulation system. After repair and restoration work, tests were continued and gave positive results. The first test of the rocket lasted only 20 seconds due to the reduction in fueling with fuel components. In subsequent tests, the operating time of the propulsion systems of all units corresponded to the operating time during flight, and the on-board flight control system deflected the steering chambers to maximum angles. In parallel with the fire tests, the undocking of ground communications and the technology for servicing the tail sections of the rocket at launch were tested at a special stand, based on the results of which the operational documentation was corrected.

- Testing the launcher maintenance cabin and checking its interface with the tail sections of the rocket blocks. These works were carried out in branch No. 2 of NII-88. Their goal was to test the operation of all the mechanisms of the service cabin, the methodology for its deployment and retraction into a niche, as well as to test the possibility and ease of servicing the tail sections of the rocket from the cabin platforms. For this purpose, a special installation was assembled, which included a real service cabin and mock-ups of the tail sections of the rocket blocks. During the testing process, the cabin was repeatedly pulled out of the niche, its platforms were raised, filling hoses were unfolded and connected to the tail sections of the rocket, as well as the cabin was folded and evacuated into the niche. Upon completion of this work, the cabin was sent to the test site for installation on the launch system.
- Testing the system for separating the side blocks of the rocket from the central block on a special installation in branch No. 2 of NII-88. The purpose of this work was to determine the actual characteristics and parameters of the block separation system. The measurement results showed that the separation system is functioning normally and its parameters do not exceed the design values.
- Development of technology for preparing a rocket for launch and interaction between the range of services. In December 1956, the first R-7SN rocket arrived at the test site for fitting and debugging work. The program of these works, as part of the overall comprehensive testing program for the R-7 missile, provided for the following:
  - in a technical position - the full scope of all mechanical assembly work on the rocket, checking the tightness of all rocket lines, checking the ease of maintenance of rocket systems from ground equipment units and working out technical documentation for preparing the rocket and training crews;
  - at the launch position - transporting the rocket, lifting it to a vertical position and installing it on the launch device, verticalization and aiming, connecting all pneumatic and hydraulic communications to the rocket, refueling the rocket with propellant components, gases and carrying out all pre -launch operations (lowering service trusses, retracting the service cabin into a niche), shooting pneumatic and hydraulic pads from the rocket, draining fuel components and evacuating the rocket from the launch position, working out technical documentation and training combat crews. During these works, the readiness for operation of all services of the landfill was monitored. Tests were carried out in December 1956 - February 1957.

In December 1956, aircraft overflights were made of all points of the polygon measuring complex located along the flight route and in the area where the warhead fell. In March 1957, the first R-7 rocket (No. 5) arrived at the technical position of the test site to conduct a flight test. The process of preparing the rocket included electrical and pneumatic tests of each block, checking the alignment of the rocket blocks after transportation, assembling the package, conducting electrical and pneumatic tests of the rocket as a whole (autonomous and complex tests), installing reciprocal pneumatic and hydraulic blocks on the rocket blocks for connection to ground lines at the launch complex, transferring the "package" to the installer and docking the head part. Compared to previously developed "products" (ballistic missiles R-1 (8Zh38, adopted by the Soviet Army in 1950, designer SP Korolev), R-2 (designer SP Korolev), R-5, R-11) the volume and complexity of the test program was unprecedented.

On April 10, 1957, the first meeting of the State Commission for Flight Tests, approved by the Council of Ministers of the USSR on August 31, 1956, took place, consisting of VM Ryabikov (chairman), MI Nedelin (deputy chairman), SP Korolev (technical manager), VP Barmina, VP Glushko, VI Kuznetsov, AG Mrykin, NA Pilyugin, MS Ryazansky (deputy technical director), SM Vladimirsky, AI Nesterenko, GN Pashkova, I.T.Peresypkina and GRUdarova. At the commission meeting, SP Korolev reported on the results of the experimental testing and on the preparation of the R-7 rocket for the start of flight tests. Strong arguments about the readiness of the rocket for flight testing were the positive results of fire bench tests of the blocks and the rocket as a whole. In his report, SP Korolev also touched upon the issue of the structure of the test crews and their personnel, the scheme for monitoring those responsible for the operation of preparing a rocket for launch (“executive-controller of the test management - controller of the Chief Designer”), which in future work, especially when preparation of manned space systems has found wide application. The flight tests were faced with the task of verifying the correctness of the fundamental solutions incorporated into the design of the rocket, engines, control system, complex of ground equipment, their development and testing in flight conditions, obtaining and accumulating experimental data on range and accuracy during launches to an estimated range of about 6300 km, and also experimental data on all systems and assemblies of the rocket, a complex of ground equipment and measuring instruments. Based on these tasks, the goals of the first launches were to test the launch technique, the dynamics of the controlled flight of the 1st stage and the process of separating the stages, and the subsequent ones were to test and test the radio control system, the flight dynamics of the 2nd stage and the movement of the warhead to the target. In addition, two of the twelve rockets intended for flight development tests, after appropriate modifications, were used to launch the first two artificial Earth satellites of the "PS" type ("The Simplest Satellite").

The second stage began on May 5, 1957, when the R-7 No. 5 rocket was transported to the launch position. The work to prepare the rocket for launch at the launch site, taking into account the novelty and responsibility, was divided into several days, in particular, the refueling of the rocket with fuel components was planned on the eighth day. The first launch took place on May 15, 1957. at 19:01 Moscow time. According to visual observations, the flight proceeded normally until 60 seconds, then changes in the flame of escaping gases from the engines became noticeable in the tail section. Processing of telemetric information showed that at 98 seconds into the flight, side block D fell off and the lost rocket stability. The cause of the accident was a leak in the fuel line. Despite the failure, this launch made it possible to obtain experimental data on the dynamics of the launch and the controlled flight of the 1st stage.

The second launch, scheduled for June 11, 1957, failed, despite three attempts: during the first two attempts, due to freezing of the main oxygen valve plate of block B, the launch circuit was reset; on the third attempt, an emergency shutdown of the propulsion systems occurred in the preliminary stage mode due to a technical error when installing the nitrogen purge valve for the oxidizer line of the central block. The missile was removed from the launcher and returned to its technical position.

The third launch took place on July 12, 1957 at 15:53. At 33 seconds into the flight, the rocket lost stability. The cause of the accident turned out to be a short to the housing of the control signal circuits of the integrating device along the rotation channel.

The fourth launch on August 21, 1957 at 15:25 was successful, and the rocket reached the target area for the first time. The main disadvantage of this launch was the destruction of the warhead in the dense layers of the atmosphere on the downward section of the trajectory, and no experimental data on the causes of this destruction were obtained, since telemetry recordings stopped 15-20s before the fall of the warhead. Analysis of the fallen structural elements of the head part made it possible to establish that the destruction began from the tip of the head part, and at the same time to clarify the amount of loss of its heat-protective coating. This made it possible to finalize the documentation for the warhead, clarify the layout, design and strength calculations, and manufacture it in the shortest possible time for the next launch. On August 27, 1957, the media published a TASS report that the Soviet Union had tested an intercontinental ballistic missile.

The fifth launch of the R-7 rocket on September 7, 1957 basically confirmed the results of the previous launch.

The positive results of the rockets' flight in the active part of the trajectory made it possible to use them to launch the first two artificial Earth satellites (of the "PS" type). Missiles No. 1PS and 2PS were used as their carriers, which were modified taking into account the tasks being solved. In general, the launch of the first two artificial Earth satellites was successful: on October 4, 1957, the first artificial Earth satellite was launched into satellite orbit, and on November 3 of the same year, a satellite with the first living creature in orbit , a dog named Laika, was launched into satellite orbit. The R-7 rocket became the “workhorse” of the Russian cosmonautics for many years. It was not only the first intercontinental missile, but also the first launch vehicle.

The launch vehicle based on the R-7 ICBM without additional upper stages was called Sputnik. Based on the results of the first six launches of the R-7 rocket, the warhead (replaced with a new one) and its separation system were modified, slot antennas of the Tral telemetry system, etc. were used, the effectiveness of which was confirmed by subsequent launches. Flight design tests of the second stage were completed with launches of R-7 missiles on May 24 and July 10, 1958, while for the first time the launch of the R-7 missile was completely successful on March 29, 1958, the rocket was equipped with a prototype of the standard M1-6A warhead. The flight design test program for experimental R-7 missiles was largely completed. Experimental data have been obtained showing the correctness of the basic fundamental decisions incorporated into the design of the rocket, engines and control system. The launch technique, the dynamics of controlled flight on stages 1 and 2, the radio control system and the separation of the warhead have been developed. Measures to ensure that the head part achieves the goal have been tested and implemented. Experimental data on the actual flight trajectory at a given range have been obtained, and the accepted guarantee reserves of fuel components are sufficient. However, the dispersion data obtained were insufficient to fully assess the accuracy, although a preliminary assessment showed that the dispersion did not exceed the design limits. The data obtained on elastic vibrations of the structure and pressure in propulsion systems with a frequency of 10-13 Hz at the 1st stage of flight was not enough to provide a comprehensive answer to this question.

In general, the R-7 rocket, taking into account the elimination within the established time frame of comments and shortcomings identified and not eliminated during the testing process, was allowed to proceed to the next stage of flight testing. The purpose of these tests was to verify the basic flight and operational characteristics of the R-7 ICBM (third stage design) in accordance with the requirements of the Resolution of May 20, 1954; checking the correctness and sufficiency of design decisions made based on the results of the LCT of the second stage R-7 missiles and determining the reliability of the missiles, the specified firing range and accuracy, and issuing recommendations on the possibility of adopting the third stage design for service with the Soviet Army.

Joint flight tests were carried out from December 24, 1958. to November 27, 1959. 16 missiles were tested, eight of which were manufactured at the Progress serial plant. The tests were preceded by control fire bench tests of a special assembly, consisting of a central and one side block, which took place in August-November 1958. at the stands of branch No. 2 of NII-88. The test on November 17, 1958, in which the side block was fixed according to the “package” scheme, confirmed the effectiveness of measures to eliminate resonant oscillations in the “elastic structure - propulsion system” circuit, which previously led to the destruction of the rocket. On the third stage rockets, the intertank instrument compartment on the central block was eliminated (the instruments were placed in a single block at the top of the blocks), steering engines with increased thrust and an improved power supply circuit were introduced, SOBIS instead of SOB (for simultaneous emptying of all tanks on each block and synchronizing them emptying within specified limits), the conditions for pressurizing the tanks were changed and a number of other design improvements were applied. Of the 16 launched missiles, 10 reached the target with the specified accuracy, two missiles exceeded the range due to deviations in the operation of the control system, one missile did not reach the target by 28 km due to abnormal operation of the oxidizer pipeline pressurization system at the final stage, one missile overshot the target by 16 .8 km due to unstable operation of the radio control system and two missiles stopped flying due to deviations in the operation of the propulsion system.

Simultaneously with the LCT, space launch vehicles were launched (the Sputnik launch vehicle and the new Vostok launch vehicle, with a third stage (block E)) based on the third stage R-7 rockets (May 1958 - November 1959). A new Soviet satellite with a record mass of 1327 kg, equipped with a large amount of scientific equipment, was launched into satellite orbit. In 1959, the Vostok launch vehicle ensured the sending of automatic interplanetary stations to the Moon.

In addition, during the development of the Vostok launch vehicle, it was possible to solve very important scientific and technical problems: launching rocket engines in a vacuum and weightlessness or alternating loads. Subsequently, the Vostok launch vehicle ensured the launch of the world's first spacecraft, Vostok-1, on April 12, 1961, which was piloted by the first cosmonaut, citizen of the USSR Yuri Alekseevich Gagarin. Improved LVs "Voskhod" and "Soyuz" (with a new, more powerful third stage "Block I") and "Molniya" (with a third stage "Block I" and a new fourth stage "Block L") were created, with the help of which the There are many new achievements in both manned and unmanned astronautics. Thus, launch vehicles based on the R-7 ICBM raised the authority of the USSR to unprecedented heights. New modifications of the Soyuz launch vehicle are still operating today, becoming the most reliable rocket in the history of astronautics. A significant role in the modernization of R-7 missiles belongs to the Kuibyshev (now Samara) branch of OKB-1, and then to TsSKB (DI Kozlov) and the Progress plant, which produces these missiles. Since 1965, the fourth stage “block L” has been supervised and manufactured at the NPO named after. Lavochkina.

See on our website the gallery *Monument to the launch pad with the Vostok launch vehicle on the territory of the All-Russian Exhibition Center (VVC) (Moscow)* .

Of particular interest is the creation of a thermonuclear warhead for the R-7 rocket. Initially, the ICBM was supposed to be equipped with a thermonuclear charge of the RDS-6s type (the world's first thermonuclear charge suitable for combat use and the first domestic thermonuclear charge, made according to a single-stage scheme, the authors of the idea were KB-11 employee AD Sakharov and employee of the USSR Lebedev Physical Institute VL Ginzburg - see photo). At the same time, it was necessary to exclude the use of lithium deuteride-tritide in this charge due to the scarcity of tritium and a significant deterioration in the operational characteristics of the charge in the case of using tritium. It was also necessary to increase the energy release of the charge.

However, estimates have shown that an RDS-6s type charge with the required power will have extremely large mass and dimensions. Therefore, it was decided to investigate the possibility of increasing the power of the RDS-6s charge in its tritium-free version through the use of an additional significant mass of fissile materials. This charge was given to the designation RDS-6sD. During its development, it gradually became clear that by using the physical design of the RDS-6s charge, the problem of creating a highly effective thermonuclear munition of the required power could not be solved.

The development of powerful thermonuclear charges according to a new two-stage scheme made it possible to abandon the path of their creation according to a single-stage scheme - the two-stage scheme of thermonuclear charges made it possible to sharply increase the specific power of ammunition, ie the ratio of ammunition power to its mass. The developed RDS-37 charge (the charge for the first domestic two-stage thermonuclear bomb, made on the basis of the idea of “nuclear implosion”, the authors of the idea were KB-11 employees VA Davidenko and AP Zavenyagin - see photo), although it is satisfied in terms of the level of energy release requirements imposed on the combat equipment of the R-7 ICBM, it required serious modernization. The development of a new charge from the very beginning began to be of an acute competitive nature between the options being developed in the country's two main nuclear centers - KB-11 (now VNIIEF, Sarov) and NII-1011 (now VNIITF, Snezhinsk) . For example, only in 1956, KB-11 conducted 5 tests of thermonuclear devices in order to improve the RDS-37 charge circuit. However, the problem could not be solved, and in three tests the thermonuclear units failed, which was a serious blow, indicating the insufficiency of the ideas available at that time about the processes occurring in charges of the RDS-37 type. At the same time, based on the RDS-37 design 37 NII-1011 was also involved in the development of powerful thermonuclear charges. In April 1957, NII-1011 at the Semipalatinsk test site tested two thermonuclear charges, which generally showed good results. Tests were carried out with a specially reduced power output in the interests of safety.

Based on the results of the work carried out, the following decision was made:

1. “to accept the KB-11 charge for the R-7 carrier, consisting of the NII-1011 thermonuclear unit and a primary atomic charge based on the RDS-4 (the first domestic charge for a tactical nuclear bomb - see photo);
2. conduct tests at full explosion power."

The charge for the R-7 rocket was tested in the body of an aerial bomb. Due to the estimated high power of the thermonuclear charge and in accordance with the decision made to conduct a full-scale test, the explosion was carried out at the Northern test site (Novaya Zemlya archipelago). On October 6, 1957, a charge in the body of an aerial bomb was dropped from a Tu-16 long-range bomber. The test was a complete success - the explosion power of the thermonuclear charge obtained after processing the data was 2.9 Mt and exceeded the calculated one by 20%. After a significant improvement of this type of charge was subsequently carried out, including in the direction of increasing the explosion power (this was caused by the relatively low accuracy of the first ICBM and caused a corresponding reduction in range due to an increase in the mass of the charge), it was put into service as part of a missile system with ICBM 8K71.

In the process of developing the design of the warhead of the R-7 missile, in addition to extensive ground-based laboratory design testing, flight design tests were carried out in order to determine the state of its structure, the temperature effect on it, the movements and deformations of components under conditions of real overloads and temperatures during the flight of the warhead. During flight development tests, the corresponding telemetric information was transmitted to ground registration systems. Flight tests showed the integrity of the design of the warhead and charge, the magnitude of overloads, temperature effects and movements of structural components were within acceptable values. In general, this allowed us to conclude that the warhead of the R-7 missile is highly reliable.

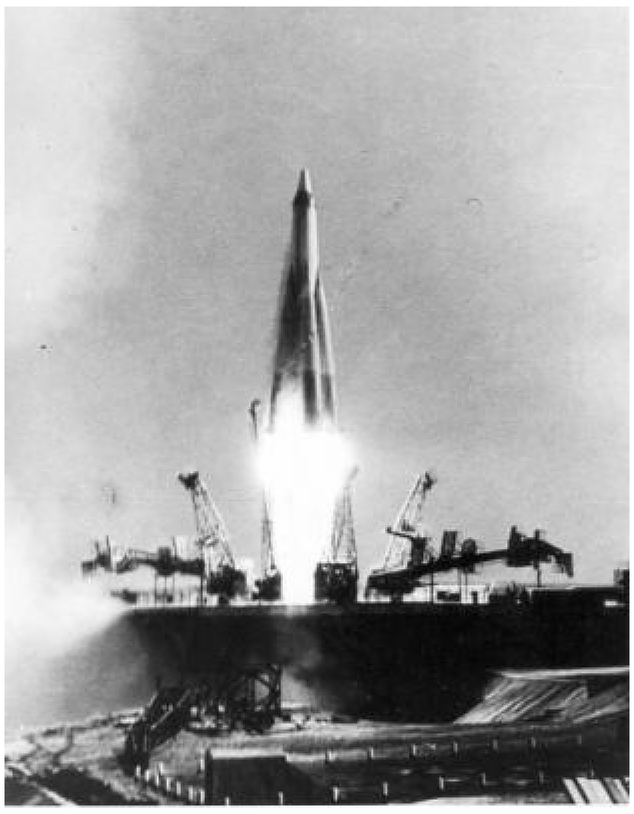
However, already in 1957, development was completed, and in 1958, the first full-scale test of a new type of thermonuclear charge, called “product 49,” was carried out. The ideologists of this project and the developers of the physical charge circuit were KB-11 employees Yu.A. Trutnev and Yu.N. Babaev. The peculiarity of the new charge was that using the basic principles of the RDS-37 charge it was possible to:

- significantly reduce overall parameters due to a new original solution to the problem of transfer of X-ray radiation, which determines the implosion of the thermonuclear unit;
- simplify the “layered” structure of the thermonuclear unit, which turned out to be an extremely important practical decision.

According to the conditions of adaptation to specific carriers, “product 49” was developed in a smaller overall weight category compared to the RDS-37 charge, but its specific volumetric energy release turned out to be 2.4 times greater. The “primary atomic charge” (according to the classification of that time, the designation is currently used as a primary nuclear unit or trigger) for “product 49” was tested autonomously back in 1957. During its development, it was possible to significantly, by 1.5 times, reduce the size of the unit , while ensuring its sufficiently high energy release. In 1958, KB-11 conducted 8 tests of devices created on the basis of “product 49”; their energy release ranged from 0.2 to 2.8 Mt.

As a result of the work carried out, at the end of 1958, KB-11 tested a new thermonuclear charge according to the “product 49” scheme to equip the improved R-7A ICBM (see photo). Compared to the charge previously developed to equip the R-7 ICBM, while maintaining the level of energy release, the weight and size parameters of the charge were radically reduced (for example, the diameter of the charge was reduced by 1.75 times). As a primary

atomic charge, a charge with tritium-deuterium gas boosting (enhanced fission reaction by "thermonuclear" neutrons) was used. The thermonuclear charge, modified based on the test results, was later adopted for service as part of a complex with the R-7A missile.



By a resolution of the USSR Council of Ministers of January 20, 1960, the R-7 (8K71) intercontinental ballistic missile was adopted by the Soviet Army. However, even during work on the R-7 rocket, it became clear that the rocket had potential for improvement. , on December 24, 1959, flight design tests of the improved R-7A (8K74) rocket began with a new design warhead (a new, lighter thermonuclear charge 46A, which, in addition to weight and size characteristics, satisfied all trajectory influences and operational requirements) and with advanced radio control system. The missile's flight range has increased significantly. Mass-saving technologies were used. The methodology for preparing the rocket for launch was also simplified. OKB-1 received the task to develop a new rocket on July 2, 1958, when the corresponding Resolution of the USSR Council of Ministers was approved. During the flight test, eight missiles were tested, seven of which completed their task. The R-7A missile was put into service on September 12, 1960, replacing the R-7 missile. According to available data, the R-7 missile was never directly on combat duty, unlike the R-7A (the latter was withdrawn from service in 1968; the maximum number of ICBMs of this type simultaneously on combat duty was no more than 5) . But it was not possible to achieve a noticeable improvement in the combat and operational characteristics of the R-7A compared to the R-7. It quickly became clear that the R-7 and its modification could not be put on combat duty in large numbers. To base these missiles, in January 1957, construction began on a combat launch station (the Angara facility) in the area of the village of Plesetsk (Arkhangelsk region, RSFSR).

According to other sources, after the completion of tests of the first complex with the R-7 missile, the question arose about organizing military units armed with this type of powerful weapon, with which it would be possible to hit the enemy almost anywhere in the world. The first formation to be armed with the R-7 intercontinental missile system was a military unit that bore the code name "Angara" object (in pursuance of the Resolution of the CPSU Central Committee and the USSR Council of Ministers of January 11, 1957) . The commander of the unit is Colonel MG Grigoriev.

In the summer of 1959, for the first time in the Armed Forces, a combat training launch from a launch position was carried out independently at the Angara facility. The first launch of the serial production MKR R-7 was carried out on July 30, 1959. On December 13, 1959, members of the state commission signed an act of acceptance into operation of the first in the USSR "MKR combat complex that began to carry out combat duty for the protection and defense of our Motherland." According to other data, on December 31, 1959, the first missile system with the R-7A ICBM was put on combat duty (part of Colonel G. Mikheev). Before launch, the rocket was delivered from the technical position on a railway transport and installation carriage and installed on a massive launch device. The entire pre-launch preparation process lasted more than two hours. The missile system turned out to be bulky, vulnerable and very expensive and difficult to operate. In addition, the rocket could remain in a fueled state for no more than 30 days. An entire plant was needed to create and replenish the necessary supply of oxygen for deployed missiles. The complex had low combat readiness (readiness for launch was at least 7 hours). The shooting accuracy was also insufficient. This type of missile was not suitable for mass deployment. In total, four launch structures were built at the Angara facility (site No. 41 "Lesobaza", site No. 16, site No. 43 (2 complexes)). There were two more at the Tyura-Tam training ground (site No. 1 "Gagarinsky Launch", site No. 31), but only one of the two (No. 31) could be used for full combat duty of ICBMs. All five launch complexes were put into service by July 1961. According to available data, in the early 60s, tests were carried out on the R-7A ICBM, equipped with a light warhead of reduced power (the maximum range reached 12,000 km), but this modification was not put into mass production.

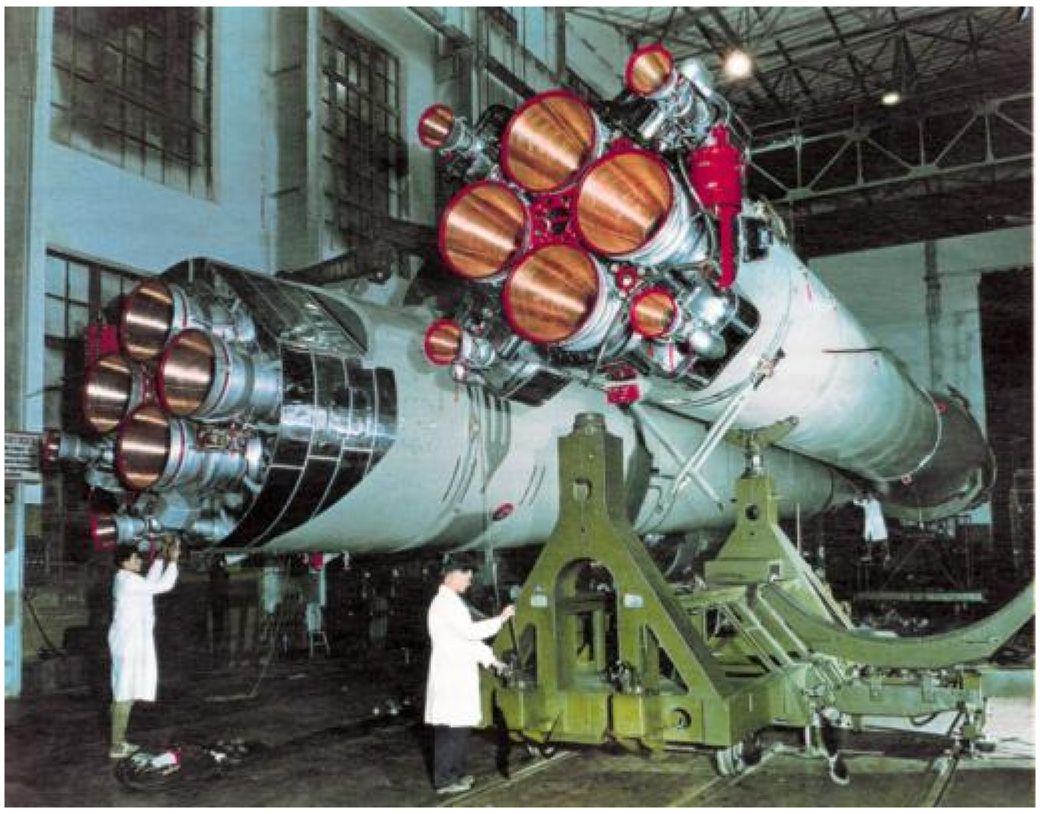
At the same time, despite all the shortcomings of the R-7 / R-7A, the mere presence of these missiles in service, albeit in small quantities, was an unambiguous signal for supporters of aggression against the USSR - it became clear that from the well-deserved retribution in the event of the outbreak of war it will no longer be possible to leave. In addition, the development of these missiles indicated that the USSR had an appropriate scientific, technical, industrial and personnel base, on the basis of which more advanced models of missiles of various classes would be developed in the near future, which was demonstrated.

Conceived and operated as a combat rocket, the R-7 rocket had a reliable and successful design, and had energy capabilities that made it possible to launch a payload of significant mass into space (into low-Earth orbit). Therefore, after successful launches of the 8K71 as a ballistic missile, it was used in 1957 to launch the world's first artificial Earth satellites. Since then, launch vehicles of the R-7 family have been actively used to launch spacecraft for various purposes, and since 1961, these launch vehicles have been widely used in manned astronautics. The reliability and success of the design made it possible to create a whole family of launch vehicles based on it. It is difficult to overestimate the contribution of the Seven, but it is even more difficult to imagine the gift of foresight of SP Korolev, who laid the foundation for Russian cosmonautics for many decades. In total, since

1957, by mid-2010, more than 1,800 missiles based on the R-7 design had already been launched, more than 97% of which were successful. Based on the already proven Soyuz-U and Soyuz-U2 launch vehicles, a significantly improved Soyuz-2 launch vehicle has been developed, which will be used not only from traditional launch sites - the Baikonur and Plesetsk test sites - but also from the territory of the cosmodrome European Space Agency "Kourou" (French Guiana, South America). Rockets based on the R-7 design will be used for many more years and can be somewhat supplanted only by the family of promising Angara launch vehicles created by the Russian cooperation of manufacturers to replace the Soyuz and Proton launch vehicles, but the beginning of a “generation change” is unlikely should be expected earlier than the end of the second half of the 2010s.

In the West, the 8K71 (R-7) missile was designated SS-6 mod.1 Sapwood, and the 8K74 (R-7A) missile was designated SS-6 mod.2 Sapwood.

Compound:



The design of the R-7 rocket (see diagram) was fundamentally different from all previously developed rockets in its layout and power schemes, dimensions and weight, power of propulsion systems, number and purpose of systems, etc. It was made according to a “package” scheme and consisted of four identical side rocket blocks (each 19 m long and with a maximum diameter of 3 m), which were attached to the central block by upper and lower belts of power connections. The design of all blocks was the same and included a support cone, fuel tanks, a power ring, a tail section and a propulsion system. Each first-stage block was equipped with an RD-107 (8D74) liquid-propellant rocket engine designed by OKB-456 with a pump supply of fuel components. RD-107 (see photo) was made in an open design and had six combustion chambers. Two of them were used as helmsmen. The central block of the rocket consisted of an instrument compartment, tanks for oxidizer and fuel, a power ring, a tail section, a propulsion engine and four steering units. The fuel tanks of all units were “load-bearing”. The engines of all five blocks began to operate from the Earth. When the stages separated, the side engines were turned off, and the central part continued to fly, being the 2nd stage.

Steering engines with swing angles combined with lines for supplying fuel components taken after the turbopump unit of the main engine had a thrust of 2.5 tf. Two steering motors were installed on each side block, and four on the central block. The creation of a steering engine required the solution of many scientific and technical problems and new designs, which found application and further development in subsequent developments. These include a combustion chamber running on liquid oxygen and kerosene T-1 fuel, cooled by kerosene and having high energy and mass characteristics for that time; sealed rotary units combined with lines for supplying fuel components, ensuring the combustion chamber swings at an angle of 45 degrees and having low friction moments; a pyrovalve operating in liquid oxygen, which made it possible to significantly reduce the thrust impulse; pyroignition device for liquid fuel when starting the combustion chamber.

The second stage was equipped with a liquid propellant rocket engine RD-108 (8D75) (see photo), similar in design to the RD-107, but distinguished by a large number of steering chambers. It developed thrust at the ground up to 75 tons and operated longer than the liquid-propellant rocket engine of the side blocks. All engines used two-component fuel: oxidizer - liquid oxygen, fuel - kerosene T-1. To ensure the operation of turbopump units of rocket engines, hydrogen peroxide was used, and liquid nitrogen was used to pressurize the tanks. To achieve the specified flight range, the designers installed an automatic control system for engine operating modes and a synchronous tank emptying system (SEB), which made it possible to reduce the guaranteed fuel supply. The design and layout of the R-7 ensured that all engines were started when starting on the ground using special pyroignition devices installed in each of the 32 combustion chambers. Sustaining liquid-propellant rockets had high energy and mass characteristics, as well as high reliability. For their time, they were an outstanding achievement in the field of rocket propulsion.

The R-7 was equipped with a combined control system. Its autonomous subsystem provided angular stabilization and stabilization of the center of mass in the active part of the trajectory. The radio subsystem corrected the lateral movement of the center of mass at the end of the active part of the trajectory and issued a command to turn off the engines, which increased the accuracy of shooting. The executive bodies of the control system were the rotating chambers of the steering motors and air rudders. To implement radio correction algorithms, two control points (main and mirror) were built, located 276 km from the starting position and 552 km from each other. Measurement of R-7 motion parameters and transmission of missile control commands was carried out by a pulsed multi-channel communication line operating in the 3-centimeter wave range using coded signals. A special counting and solving device, located at the main point, made it possible to control the flight range; it gave the command to turn off the second stage engine when a given speed and coordinates were reached.

The autonomous control equipment was very cumbersome and was located mainly in the intertank compartment of the central unit in large (about 1 m high) cassette racks. The control system included an automatic stabilization system, providing normal and lateral stabilization, apparent speed control, and a radio range and direction control system. With the package scheme adopted for the R-7 rocket, it was impossible to do without adjusting the propulsion systems. At first, they decided to limit themselves to only the most necessary systems, so a system for regulating the simultaneous emptying of tanks was installed on the central unit, because the absence of such a system led to a large loss of range.

The head part of the R-7 rocket, which should enter the dense layers of the atmosphere at a speed of 7900 m/s (which is 2.5 times the speed of the head part of the R-5 rocket), was a cone with a half-angle of 110 degrees, a length of 7.2 m and weighing 5500 kg.

Characteristics:

	R-7 (8K71)	R-7A (8K74)
Maximum firing range, km	8000	9500
Maximum launch weight, t	283	276
Dry weight of the rocket with warhead, t	27	-
Total mass of fuel filled rocket, t	more than 250	250
Head mass, t	5.4	3.7
Warhead power, Mt.	5	3
Dimensions, m: - length of the rocket - length of the central block of the rocket - length of the warhead - maximum transverse size of the assembled package	 33 19.2 3.5 10.3	 31.4 - - 10.3
Thrust of the first stage propulsion engine, tf: - near the Earth - in vacuum	 82 100	 82 100
Specific thrust impulse of the first stage propulsion engine, kgf•s/kg: - near the Earth - in vacuum	 252 308	 252 308
Operating time of the first stage, s	120	-
Mass of the first stage propulsion engine, t	1.155	1.155
Thrust of the second stage propulsion engine, tf: - near the Earth - in vacuum	 75 94	 75 94
Specific thrust impulse of the second stage propulsion engine, kgf•s/kg: - near the Earth - in vacuum	 243 309	 243 309
Operating time of the second stage, s	290	-
Mass of the second stage propulsion engine, t	1.25	1.25

Testing and operation:

When forming missile units and formations armed with the R-16 and R-9A missile systems, the experience of forming and constructing the country's first facility intended for the R-7 intercontinental missile system was used.

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Analogues by purpose and location:

SM-62A Snark ground-launched strategic cruise missile

Strategic missile system R-16 with 8K64 missile (R-16U/8K64U)

R-14 medium-range missile system with 8K65 missile (R-14U/8K65U)

Atlas family of intercontinental ballistic missiles